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(54) **Pen alignment method**

Verfahren zum Ausrichten von Schreibstiften

Méthode d'alignement de plumes

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Description

Technical Field

The present invention relates generally to plural pen alignment solutions for ink-jet printers. More particularly, the invention concerns such method that provides a low-cost two pen alignment solution that user-interactively, semi-automatically compensates for misalignments between field replaceable monochrome, e.g. black and tri-color, e.g. magenta, cyan and yellow, pens within an ink-jet printhead carriage.

Background Art

Previously, plural ink-jet pen alignment problems have been avoided by maintaining extremely tight tooling and manufacturing tolerances for the pens, the carriage that holds them, and the drive system that reciprocates it. Naturally, such solutions result in high capital outlays, heavy assemblies and high-power motors that increase the complexity and cost of ink-jet printers. Alternatively, expensive optical drop detectors have been added to plural pen ink-jet printers to detect ink droplets when they are ejected from the printhead and automatically to move the pens within the carriage to improve their alignment. Other printers are equipped with detectors for detecting the position of each pen within the carriage and means for correcting the respective drop firing times so that proper alignment is achieved (e.g. US-A-5 109 239 and US-A-5 049 898. Whether the drop or position detector is placed on- or off-carriage, such solutions require large and heavy hardware that greatly increase the cost of ink-jet printers.

Disclosure of the Invention

The invented plural pen alignment solution involves user interaction with automatic pen alignment firmware to select the best alignment among a number of illustratively printed options. The alignment algorithm is invoked by a keystroke on the ink-jet printer's control panel, typically when a new pen is installed in the printer's carriage. The printer prints stored horizontal and vertical alignment test patterns that illustrate a range of alignment options including one each that should be optimal. The printer also prints a stored illustration of the printer's control panel keys that may be struck to make selected alignments. The user simply examines the printout, selects desired alignments and strikes the indicated key on the panel. Horizontal alignments are made in firmware by shifting the timing between nozzle firings in 300 dots per inch (300 dpi) increments. Vertical alignments are made in firmware by shifting the pixel image, i.e. selecting different nozzles for firing, also at 300 dpi resolution. The printer prints a page of alignment patterns illustrating the chosen alignments, which are stored in non-volatile memory.

These and additional objects and advantages of the present invention will be more readily understood after a consideration of the drawings and the detailed description of the preferred embodiment.

Brief Description of the Drawings

Fig. 1 illustrates a horizontal alignment test pattern that is printed in accordance with the preferred plural pen alignment solution.

Fig. 2 illustrates a pictorial representation of a keypad that is printed in accordance with the invented solution.

Fig. 3 illustrates a vertical alignment test pattern that is printed in accordance with the preferred solution.

Fig. 4 illustrates a confirmation alignment pattern that is printed in accordance with the preferred solution.

Fig. 5 shows the physical layouts of a monochrome and a tricolor ink-jet pen's orifices.

Detailed Description of the Preferred Embodiments and Best Mode of Carrying Out the Invention

Fig. 1 shows plural instances of superposed first and second horizontal alignment patterns that are printed by a controller within an ink-jet printer as part of the invented plural-pen alignment method. Within imposed black-and-white drawing constraints, the patterns will be understood to represent plural instances of a first stored alignment pattern that are in printed predefined positions on a page utilizing a first pen, e.g. a black pen, which first pattern labeled K includes a collinear set of spaced line segments. As may be seen, the plural instances themselves are preferably laterally, evenly spaced. Corresponding plural instances of a second stored alignment pattern are printed utilizing a second pen, e.g. a magenta pen, which second pattern labeled M includes a collinear set of spaced line segments that generally or nominally are in alignment with, i.e. collinear with, and interpose, the spaced line segments of the first pattern. Each of the plural instances of superposed first and second patterns includes and is identified by one or more pattern identifiers, or printed indicia, e.g. the printed numbers 1 through 7 printed adjacent the designated superposed patterns. As will be seen by reference to Fig. 2, such indicia correspond with user selectable keys on a keypad that part of the ink-jet printer's control panel.

Fig. 1 illustrates that the plural instances of second alignment pattern M are printed in a range of predefined positions relative to the first pattern instances with a predefined offset, or horizontal shift, of pattern M between successive instances, e.g. the second pattern starts to the left of first pattern K in instance 1 and progressively shifts to the right so that it end to the right of first pattern K in instance 7. The successive shifts may be seen to be transverse, and preferably perpendicular, to axes defined by the collinear segments of second

alignment pattern M. The predefined relative positions may be seen nominally to include at least one of the positions of the first pattern, e.g. the superposed patterns labeled 4 in Fig. 1 nominally are aligned. Superposed first and second patterns K, M may be understood to define a number of inter-pen alignment options that are useful to the user in selecting a desired alignment, for example, after installing a new pen into the printer's printhead carriage.

It will be appreciated that, due to black-and-white drawing constraints and for the sake of clarity in illustrating the invented method and apparatus, the offsets in Fig. 1 (as well as those in Fig. 3, as will be seen) are greatly exaggerated to render them more easily discernable and understandable. In actual practice, the horizontal offsets (as well as the vertical) preferably provide a range of approximately ±3 dots at 300 dpi. It also will be appreciated that, for the same reasons, the offset of the middle horizontal alignment pattern in Fig. 1 (as well as the corresponding vertical alignment pattern in Fig. 3 and the corresponding confirmation alignment pattern in Fig. 4) typically would not exhibit the intentionally exaggerated offset, but instead would exhibit perfect or near-perfect alignment between the first and second superposed patterns, thereby achieving the purpose of the invented method and apparatus.

Turning to Fig. 2, a pictorial representation of the printer's control console keypad is shown. Such a pictorial representation preferably is printed with, and most preferably on the same page as are, the plural instances of superposed alignment patterns K, M, when the invented alignment process is invoked. The keypad representation includes selected keys of the keypad identified by, thus visually to promote an association with, printed indicia corresponding with the printed, superposed patterns-adjacent, identifying indicia shown in Fig. 1 to identify the plural superposed alignment pattern instances that represent inter-pen alignment options. Accordingly, by the preferred method illustrated herein, the printed key indicia are the numbers 1 through 7 within circles indicating by the arrows the corresponding keys. It will be appreciated that, while an actual keypad is not shown, the pictorial representation of Fig. 2 is laid out substantially accurately to portray the actual physical keypad on the printer's operator's console, so that it is abundantly clear to the user which key of the physical keypad will effect which alignment pattern selection.

It will be appreciated that any printed symbol may be used as a pattern identifier so long as there is an associable selection identifier having a corresponding printed symbol in the pictorial representation. For example, letters may be used instead of numbers, or graphic symbols may be used instead of alphanumeric symbols. Or the pattern instances may be printed within the corresponding keys of the pictorial representation, as a printed symbol recognizable to the user as indicating which key selection will result in which alignment selection. It is also within the spirit and scope of the invention to color code the keys of the pictorial representation, or even the alignment patterns themselves (e.g. using various primitive color combinations to print the second alignment patterns), to colored keycaps of the control console, thereby obviating the pictorial keypad representation.

Once the superposed, plural instances of first and second alignment patterns 1 through 7 of Fig. 1 and the pictorial representation of the keypad of Fig. 2 are printed on a page of printer paper, preferably along with suitable printed instructions to the user (not shown) to make a selection of the alignment option that is seen to be most desirable, the user inputs a selected key from the keypad by any suitable manual desired alignment selection means, e.g. by depressing the key on the printer's keypad that corresponds with the desired alignment. Thus, manual selection means include plural selection identifiers associable with the plural pattern identifiers. The printer's controller reads the keyed input from the user, and correlates the key positional information illustrated in Fig. 2 with the alignment pattern positional information illustrated in Fig. 1. Responsive to the key selection by the user, the controller stores in a preferably non-volatile memory location the chosen alignment criteria, or information regarding the predefined offset corresponding with the user-inputted key. For example, if the user selects key 4, then the controller stores in memory the predefined offset information corresponding with the printed second alignment pattern of instance 4 of Fig. 1. Thereafter, i.e. after the alignment procedure is complete, the printer's controller utilizes this stored predefined offset corresponding with the second pen for all printing that is destined therefor.

The result is semi-automatic, user-interactive inter-pen alignment by which the user is able to participate in the selection of the inter-pen alignment or registration. If the tri-color pen is placed in the printer's carriage at a slight lateral offset from the already installed black pen, i.e. either too close to or too far from the black pen, nevertheless near perfect inter-pen alignment can be had when ink-jet printing because the controller, with the user's help, adjusts the timing of its horizontal ink-jet firing sequences as between the black and the tri-color pen so that extremely close alignment or registration in the printed output is maintained. It will be appreciated that horizontal alignment only is illustrated in Figs. 1 and 2, whereas preferably vertical alignment also is provided.

Fig. 3 illustrates a variation on the superposed first and second alignment patterns shown in Fig. 1 that facilitates vertical, in addition to horizontal, inter-pen alignment. In Fig. 3, which represents a second page of printed output of the inter-pen alignment method, plural instances of a first stored alignment pattern are printed utilizing a first pen, e.g. a black pen, with the first pattern again including a set of collinear, spaced line segments. Also plural instances of a second stored alignment pattern are printed utilizing a second pen, with the second pattern including a set of collinear spaced line seg-

ments nominally collinear with and interposing the spaced line segments of the first pattern, and with a predefined offset of the second pattern relative to the first between the successive instances of the first. Again, the offset is transverse to parallel axes defined by the collinear segments of the second pattern. Plural superposed patterns including first patterns (labeled K) and second patterns (labeled M) are produced. Again, each superposed pattern instance is identified by one or more printed indicia such as numbers 1 through 7.

As may be seen, in this vertical alignment phase the superposed collinear line segments extend along horizontal axes (perpendicular with those printed during the horizontal alignment phase), or parallel with the printhead's scan axis. Thus, the superposed patterns represent a predefined range of vertical alignment options. Again, after the printing of the superposed alignment patterns illustrated in Fig. 3, the keyboard representation of Fig. 2 is printed, preferably on the same page as the vertical alignment patterns. The user is instructed as before to choose the desired alignment pattern instance by depressing the correspondingly numbered key on the printer's operator console keypad. With the selection made and inputted by the printer's controller, information regarding the predefined offset corresponding with the selected pattern instance is stored in preferably non-volatile memory and thereafter utilized for printing by the second pen, e.g. the tri-color pen that printed the magenta segments (labeled M in Fig. 3). It will be appreciated that vertical alignment in accordance with the preferred method of the invention is accomplished by pixel or orifice shifting to-be-printed images prior to printing, which will be described by reference to Fig. 5.

It now may be seen that first and second alignment patterns, as collectively illustrated in Figs. 1 and 3, include both vertical and horizontal line segments, thereby defining respectively an array of horizontal and vertical inter-pen alignment options and providing respectively for a horizontal and a vertical alignment user selection. By storing desired alignment information in non-volatile memory by the controller, the invented method and apparatus preserve the desired alignment criteria memory contents even when the printer is turned off or power is otherwise interrupted. Accordingly, it is necessary for the user interactively to align the pens only if and when one or more has been installed or replaced.

Turning now to Fig. 4, a further step of the preferred alignment method is illustrated. Fig. 4 shows a page that is printed by the printer's controller after the user has made desired horizontal and vertical alignment selections. A box and a cross are printed in accordance with the preferred method, again with collinear spaced line segments being printed by the first pen and with interposing and now more accurately aligned and collinear spaced line segments printed by the second pen. Again for illustration purposes, those segments that are printed by the monochrome pen are labeled K (for black) and those segments that are printed by the tri-color pen are labeled M (for magenta). Thus, after the storing and before the utilizing of the information by the controller, derived from the user's selection, the controller preferably prints an alignment pattern based thereon as confirmation of the user's selection. Of course, if the alignment pattern does not represent the desired horizontal and vertical alignment, the user may simply repeat the above-described alignment process until a desired alignment, as indicated by the confirmation printout, is achieved.

Those skilled in the arts will appreciate that the successive predefined horizontal and vertical offsets illustrated, respectively, in Figs. 1 and 3 define an offset range that has been predetermined to correspond to a range of possible inter-pen alignments within the printhead carriage, as determined by analyzing printer manufacturing tolerances. Importantly, such manufacturing tolerances may be higher, and thus the ink-jet printer cost may be lower, because of the inter-pen alignment method of the invention. Moreover, because the preferred method is user-interactive, semi-automatic, and implemented in firmware executed by the printer's existing controller, its provision imposes negligible cost on the purchaser and user of the printer. It is believed that ink-jet printer users are eager to participate in the inter-pen alignment process, which is infrequently required and which builds user confidence in high print quality.

Fig. 5 shows the two-pen ink-jet printer printhead configuration including the nozzle or orifice layout for each pen (with greatly exaggerated inter-orifice spacing, for the sake of clarity). It will be appreciated that the range over which successive horizontal and vertical second alignment patterns are printed with offsets or positions, as illustrated in Figs. 1 and 3, are defined to a great extent by the geometries of the printhead's pens and the carriage that fixedly locates them relative to one another. To accommodate replaceability of the pens within the printer's carriage, thus to greatly extend the printer's useful life, the pens necessarily must be only temporarily fixedly captured within the printhead carriage. This need creates the possibility of inter-pen misalignment or mispositioning over a finite, predefined range best described as a lateral separation variance of the nominal separation of the "home" position orifices of the individual pens.

The pens as shown are side by side in the printer's carriage, in nominally fixed, absolute and relative positions in the horizontal and vertical axes. Because their fixed positions within the carriage are only nominally determinable, due to the relatively high manufacturing tolerances that make replacement possible, the pens may be described as being positioned relative to one another within a predefined vertical and horizontal range. With this range defined, it is a simple matter to predefine the range of offsets represented by the succession of plural instances of relatively shifted second alignment patterns associated with the tri-color pen the output of which is labeled M in Figs. 1 and 3 so that it is

associable with the range of pen alignment or position possibilities.

The tri-color pen on the right of Fig. 5 will be understood to represent a "paper's eye" view of the pen. The same is true for the black pen shown on the left of Fig. 5. The two pens' home orifices nominally are separated center to center by approximately 34 millimeters (34 mm). The tricolor pen has three identical but differently positioned sets of bi-line orifices, one for each of the magenta, cyan and yellow ink reservoirs contained therein. The black pen appears from Fig. 5 to have a singular oval set of orifices, but in fact, it too has two columns of operative orifices, generally as described above regarding the tri-color pen (the oval-closing end orifices are non-printing). It is important to remember that the printhead carriage containing the pens passes from right to left in Fig. 5, or perpendicularly to the long axes of the columnar, bi-line orifice sets. The inter-orifice spacing is 0.17 mm (150^{-1} inch), but the orifices on either side of the patterns are vertically offset from one another by one-half of their center-to-center spacing. Effectively, 2 X 150 = 300 dpi vertical resolution results.

It is this vertical resolution and orifice layout of the pens that determines the minimum successive vertical offset between adjacent spaced instances of the second alignment patterns in Fig. 3. Offsets are accomplished by simply bit shifting, or pixel shifting, the to-be-printed images by up to ±3 pixels prior to printing. The alignment patterns are so created, as are normal images printed after a desired, user-selected offset is inputted during vertical alignment. There is no such pixel shifting possible along the horizontal axis, because the inter-orifice separation is far too great to provide the needed horizontal resolution for horizontal alignment. This is why horizontal alignment is accomplished by time shifting, i.e. advancing or retarding, the firing of the ink jets. Such time shifting straightforwardly is performed by the controller executing firmware resident in a read-only memory (ROM) therein.

Industrial Applicability

It may be seen then that the invented plural pen alignment solution is generally applicable to pen alignment problems that heretofore have been solved in complicated and expensive ways. By making the solution semi-automatic, so that users play a role in selecting preferred alignment patterns, much of the cost of fully automatic solutions is avoided altogether, with cost savings in tooling, manufacturing, calibrating, testing and field servicing ink-jet printers more than compensating the users for their modest effort. By making the solution logical (or virtual), rather than mechanical, the cost is borne one time in modest firmware development of the alignment test patterns and the alignment algorithm, which straightforwardly shifts the timing of nozzles' firings and selects the nozzles to achieve user-selected, visually optimized horizontal and vertical plural-pen print alignment.

While the present invention has been shown and described with reference to the foregoing operational principles and preferred embodiment, it will be apparent to those skilled in the art that other changes in form and detail may be made therein without departing from the scope of the invention as defined in the appended claims.

Claims

1. A user-interactive plural-pen ink-jet printer alignment method comprising: printing plural instances of a first stored alignment pattern utilizing a first pen, said first pattern including a collinear set of spaced line segments (K); printing plural instances of a second stored alignment pattern utilizing a second pen, said second pattern including a collinear set of spaced line segments (M) nominally collinear with said spaced line segments of said first pattern and interposing the same, with a predefined offset of said second pattern between successive instances transverse to the axes defined by the collinear segments of said second pattern, to produce plural superposed patterns; identifying each of said superposed patterns with one or more printed indicia (1, 2, 3, 4, 5, 6, 7) corresponding with one or more user selectable keys on a keypad of the printer; inputting a user's key selection from the keypad; storing information regarding the predefined offset corresponding with said second pattern identified by the user-inputted key; and thereafter utilizing the predefined offset corresponding with the second pen for printing thereby.

2. The method of claim 1 which further comprises, after said storing and before said utilizing, printing an alignment pattern based upon the stored information as confirmation of the user's selection.

3. The method of claim 1, wherein said predefined first and second alignment patterns include both horizontal and vertical line segments.

4. The method of claim 1, wherein said successive predefined offsets define an offset range predetermined to correspond to a range of possible inter-pen alignments within the carriage.

5. The method of claim 1, wherein said identifying is performed by printing indicia (1, 2, 3, 4, 5, 6, 7) adjacent said plural superimposed patterns that correspond with indicia associated with the keys of the keypad.

6. The method of claim 5, wherein said identifying is performed by printing a pictorial representation of the keypad, with one or more keys of said pictorial keypad representation containing printed indicia corresponding with the printed identifying indicia (1,

2, 3, 4, 5, 6, 7).

7. The method of claim 1, wherein said storing is in non-volatile memory the contents of which are preserved when the printer is turned off.

Patentansprüche

1. Ein Anwender-interaktives Ausrichtungsverfahren für einen Tintenstrahldrucker mit einer Mehrzahl von Stiften, mit folgenden Schritten:

   Drucken einer Mehrzahl von Beispielen eines ersten gespeicherten Ausrichtungsmusters unter Verwendung eines ersten Stiftes, wobei das erste Muster einen kollinearen Satz von beabstandeten Liniensegmenten (K) einschließt;

   Drucken einer Mehrzahl von Beispielen eines zweiten gespeicherten Ausrichtungsmusters unter Verwendung eines zweiten Stiftes, wobei das zweite Muster einen kollinearen Satz von beabstandeten Liniensegmenten (M) einschließt, die nominell kollinear mit den beabstandeten Liniensegmenten der ersten Struktur sind und zwischen diesen liegen, mit einer vorbestimmten Verschiebung der zweiten Struktur zwischen aufeinanderfolgenden Beispielen quer zu der Achse, die durch die kollinearen Segmente der zweiten Struktur definiert ist, um eine Mehrzahl von überlagerten Mustern zu schaffen;

   Identifizieren jedes der überlagerten Muster mit einem oder mehreren gedruckten Indizes (1, 2, 3, 4, 5, 6, 7), die einer oder mehreren Anwender-auswählbaren Tasten einer Tastatur des Druckers entsprechen;

   Eingeben einer Tastenauswahl des Anwenders von der Tastatur aus;

   Speichern von Informationen bezüglich der vorbestimmten Verschiebung, die dem zweiten Muster entsprechen, das durch die Anwender eingegebene Taste identifiziert ist;
   und danach

   Verwenden der vorbestimmten Verschiebung, die dem zweiten Stift entspricht, um damit zu drucken.

2. Das Verfahren nach Anspruch 1, das ferner nach dem Speichern und vor dem Verwenden das Drukken eines Ausrichtungsmusters auf der Grundlage der gespeicherten Informationen als Bestätigung der Auswahl des Anwenders umfaßt.

3. Das Verfahren nach Anspruch 1, bei dem die vorbestimmten ersten und zweiten Ausrichtungsmuster sowohl horizontale als auch vertikale Liniensegmente einschließen.

4. Das Verfahren nach Anspruch 1, bei dem die aufeinanderfolgenden vorbestimmten Verschiebungen einen Verschiebungsbereich definieren, der vorbestimmt ist, um einem Bereich von möglichen Zwischenstiftausrichtungen innerhalb des Wagens zu entsprechen.

5. Das Verfahren nach Anspruch 1, bei dem die Identifizierung durch Drucken der Indizes (1, 2, 3, 4, 5, 6, 7) benachbart zu der Mehrzahl von überlagerten Mustern durchgeführt wird, die den Indizes zugeordnet sind, die den Tasten der Tastatur zugeordnet sind.

6. Das Verfahren nach Anspruch 5, bei dem das Identifizieren durch Drucken einer bildlichen Darstellung der Tastatur durchgeführt wird, wobei eine oder mehrere Tasten der bildlichen Tastaturdarstellung gedruckte Indizes enthalten, die den gedruckten Identifikationsindizes (1, 2, 3, 4, 5, 6, 7) entsprechen.

7. Das Verfahren nach Anspruch 1, bei dem das Speichern in einem permanenten Speicher erfolgt, dessen Inhalt beibehalten wird, wenn der Drucker ausgeschaltet ist.

Revendications

1. Procédé d'alignement pour une imprimante à jet d'encre à plumes multiples, à interactivité avec l'utilisateur, comprenant les phases consistant à : imprimer des exemplaires pluraux d'une première configuration d'alignement stockée en utilisant une première plume, ladite première configuration comprenant un jeu colinéaire de segments de lignes espacés (K) ; imprimer des exemplaires pluraux d'une deuxième configuration d'alignement stockée en utilisant une deuxième plume, ladite deuxième configuration comprenant un jeu colinéaire de segments de lignes espacés (M) nominalement colinéaires avec lesdits segments de lignes espacés de ladite première configuration et les interposer, avec un décalage prédéterminé de ladite deuxième configuration entre les exemplaires successifs transversalement aux axes définis par les segments colinéaires de ladite deuxième configuration, pour produire configurations plurales superposées ; identifier chacune desdites configurations superposées avec un ou plusieurs indices imprimés (1, 2, 3, 4, 5, 6, 7) qui correspondent à une ou plusieurs touches d'un pavé de touches de l'imprimante qui peuvent être sélectionnées par l'utilisateur ; entrer une sélection de touches d'utilisateur prise dans le

pavé de touches ; stocker une information concernant le décalage prédéfini qui correspond à ladite deuxième configuration identifiée par la touche entrée par l'utilisateur : et, ensuite, utiliser le décalage prédéfini correspondant à la deuxième plume pour imprimer au moyen de celle-ci.

2. Procédé selon la revendication 1, qui comprend en outre, après ledit stockage et avant ladite utilisation, l'impression d'une configuration d'alignement basée sur l'information stockée en tant que confirmation de la sélection de l'utilisateur.

3. Procédé selon la revendication 1, dans lequel lesdites première et deuxième configurations d'alignement prédéterminées comprennent à la fois des segments de lignes horizontaux et des segments de lignes verticaux.

4. Procédé selon la revendication 1, dans lequel lesdits décalages prédéfinis successifs définissent un intervalle de décalages prédéterminés pour correspondre à un intervalle d'alignements possibles entre plumes dans le chariot.

5. Procédé selon la revendication 1, dans lequel ladite identification est exécutée en imprimant des indices (1, 2, 3, 4, 5, 6, 7) adjacents auxdites configurations plurales superposées qui correspondent à des indices associés aux touches du pavé de touches.

6. Procédé selon la revendication 5, dans lequel ladite identification est exécutée en imprimant une représentation graphique du pavé de touches, une ou plusieurs touches de ladite représentation graphique du clavier pavé de touches contenant des indices imprimés qui correspondent aux indices d'identification imprimés (1, 2, 3, 4, 5, 6, 7).

7. Procédé selon la revendication 1, dans lequel ledit stockage est exécuté dans une mémoire non volatile dont le contenu est préservé lorsqu'on éteint l'imprimante.

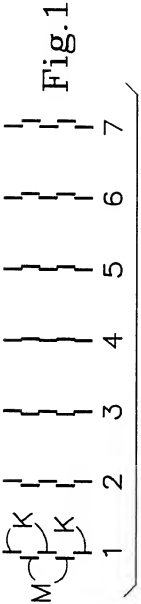

Fig.1

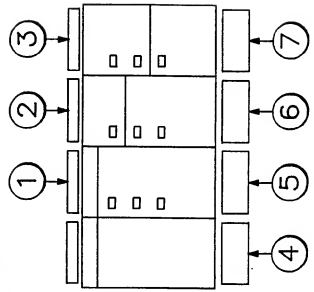

Fig.2

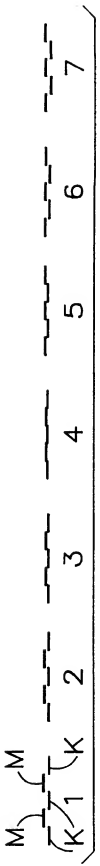

Fig.3

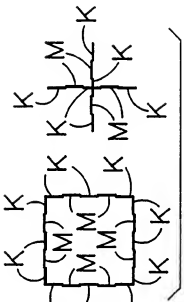

Fig.4

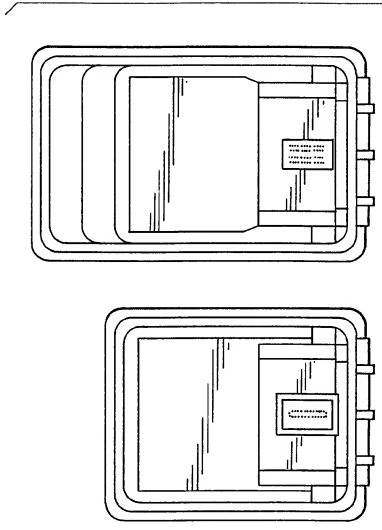

Fig.5